To begin with fishes: we will take as our first example the very beautiful genus Beryx, a fish not unlike our sea-bream, found widely distributed through the deep seas, and extending to about 40° on each side of the equator. Like the perch or the sea-bream, it is a greatly *specialised* fish; the head is immensely large, the bony rays supporting the fins hard and unjointed, the ventral fins or representatives of the hind limbs situated just behind the head, under the throat, the operculum curiously ornamented, and the air-bladder completely shut off from the gullet; thus differing very markedly from a more *generalised* fish such as the herring or carp, in which the head is proportionally much smaller, the fin-rays soft and jointed, the ventral fins far back, the operculum not ornamented, and the air-bladder communicating by a duct with the œsophagus.

We now know that at depths greater than five or six hundred fathoms, the sea-bottom is to a great extent composed of a very fine greyish-white mud, sticky when first removed from the water, but afterwards hardening into a delicate friable stone, not at all unlike chalk. This mud, which is largely made up of shells of the minute marine organism *Globigerina*, forms the bed of thousands of square miles of sea in which Beryx lives, and there can be no doubt that when the fish dies it sinks to the bottom, and, its soft parts being destroyed, becomes gradually imbedded in the soft mud, there to remain until the present sea-bottom is upheaved and becomes dry land.

Now, as a matter of archæological evidence, what is known of the history of Beryx and of the source whence it proceeded? Naturally it is useless to seek for such evidence except in deposits formed under like conditions to those in which the fish lives at the present day. Through the whole of the Pliocene and Miocene epochs no deep-sea formations are known, but in the middle of the Eocene period—a time so remote that tropical plants flourished on the banks of the Thames, and crocodiles abounded in this country—we are acquainted with an extensive deep-sea deposit, the Nummulitic limestone, which, besides the fossil giving it its name, contains large quantities of Globigerina, in all essential respects like that of the present day. In this formation are found two forms closely allied to Beryx, but with such slight differences as to receive different generic names; these are known as Acanus and Pristigaster. On passing from the Eocene or lowest tertiary to the chalk or uppermost secondary formation, which bears the closest possible resemblance to the modern Atlantic mud—the two may, in fact, be looked upon as belonging to one continuous series of deposits—we find an actual Beryx, a fish differing no more from the modern Berices than the various modern species of Beryx do from one another. This fossil, owing to the fineness of the chalk-forming mud in which it was buried, is so perfectly preserved, that all the details of structure of its hard parts, even to the ornamentation of the scales, can be compared with those in the recent fish; and in this way the most conclusive evidence is obtained that the differences which separate it from its modern relatives are of no greater importance than those by which the recent species of Beryx are distinguished from one another.

Thus we have positive evidence that a fish altogether like the Beryx of the present day, existed millions of years ago, before the Alps, the Himalayas, or the Rocky Mountains were upheaved, and has continued to live ever since. In face of these facts we cannot but conclude that the modern Beryx is derived from that of the chalk, and that the hypotheses of its creation out of nothing, and of its origin from inorganic matter are, for scientific purposes, simply non-existant.

As to the form from which the Beryx of the chalk was derived, we have absolutely no evidence, for there is no trace of any such fish in any lower formation.

We now pass on to a fish of a far older and less specialised type than Beryx—the genus *Ceratodus*, recently discovered in Australia. This animal, which attains a length of six feet, is distinguished by the possession of very curious fins, consisting of a central lobe, with a surrounding fringe of fin-rays, and by the character of its teeth, which are produced into curious horn-like processes, so arranged that those of opposite jaws interlock. Ceratodus is probably a vegetable feeder, lives in fresh or brackish water, and is said sometimes to leave its native element and crawl about among the weeds on the bank. It is enabled to do this by the fact that it can breathe air directly as well as air dissolved in water; it has, in fact, besides gills, an organ which is altogether a half-way house between the air-bladder of a fish and the lung of an amphibian.

In the Wealden, the most recent estuarine deposit of which we have any knowledge, there is no trace of Ceratodus to be found, but this is hardly surprising, as only two or three small patches of the earth's surface formed at this epoch have been examined, and animals have a geographical distribution at all times. But on passing back to the Trias, a formation as far from the chalk in point of time as the chalk from the present day, we find teeth belonging to an undoubted Ceratodus, in shape and in microscopic structure, exactly like those of the modern Australian fish. No other remains of the Triassic Ceratodus have as yet been found, but teeth are known to be so important a diagnostic character that no naturalist would have any hesitation in naming the genus to which the fish bearing such teeth should be assigned.

Thus we have a far more astonishing example of a persistent type than was afforded by our Beryx, and as in the case of the latter fish, all trace of the actual genus Ceratodus is lost at this point, and we are obliged to content ourselves with a few singular hints as to the way in which the type has come about. The most valuable of these hints are obtained by a study of a singular group of fish found in great abundance in the Old Red Sandstone. These are distinguished by the possession of curious fringed fins, unlike those of any other fish except Lepidosiren and Ceratodus—in fact, one genus, Dipterus, has fins quite like those of Ceratodus, and its teeth and skeleton were formed on just the same type. It is doubtful whether there is any relation between Ceratodus and Dipterus in the way of ancestry, but the resemblance between them is remarkable.

It must seem rather strange for a known evolutionist to select as examples two fish like Beryx and Ceratodus, which, of all others, seem most likely to support the notion that species are immutable. The adverse side only of the question has been stated to-night, the other side will be treated of on future occasions.

THE OLD RED SANDSTONE

At a meeting of the Glasgow Geological Society on the 24th ult., Sir William Thomson, F.R.S., president, in the chair, Prof. Geikie, F.R.S., communicated the results of recent researches into the "History of the Deposits known as the Old Red Sandstone." After a preliminary outline of our present knowledge on the subject, he proceeded to consider the development of the Old Red Sandstone in the British Isles under its accepted three-fold division into Lower, Middle, and Upper. The Lower member, wherever its true base can be seen, is found to pass down conformably into the Upper Silurian rocks. But a well-marked line of demarcation, both by physical characters and fossil evidence, runs between the two systems. The Silurian formations continue replete with organic remains up to their uppermost zone; but on entering the red strata of the overlying system we meet with a remarkably abrupt change, for the fossils almost wholly disappear, and those which occur belong for the most part to fishes and crustaceans. The author pointed out the geological evidence in favour of great terrestrial oscillations as explained by Prof. Ramsay, whereby the bed of the Silurian sea in our area came to be raised into land with wide lakes and inland seas. He showed that the beginnings of the movements which led to those results could be traced back a considerable way into the Silurian period, that over large tracts the Silurian deposits had been upraised before the close of that period, and that the oscillations continued during the accumulation of the Lower Old Red Sandstone, as indicated by the coarse conglomerates, the great mass of the deposits, and the unconformabilities traceable in them. Recent detailed work of the Geological Survey has brought to light the fact that this lower division of the Old Red Sandstone attains an almost incredible thickness. In Lanarkshire and Ayrshire Mr. B. N. Peach has found it to measure 15,000 feet. In Perthshire, from the combined surveys of Mr. Peach and Mr. R. L. Jack, it has been ascertained to reach a depth of more than 19,000 feet. But the author has found that traced eastward into Forfarshire and Kincardineshire, its thickness rises above 20,000 feet. And yet in no case is its top actually seen, since it has either been removed by denudation, or buried under some more recent unconformable formation. Nor is its base to be found, since along the flank of the Grampians a great fault runs from the North Sea at Stonehaven to the estuary of the Clyde, with the effect of throwing the strata of the Old Red Sandstone on end, sometimes for a distance of two miles from the line of the dislocation. The amount of displacement must be in some places not less than 5,000 feet, as indicated by the position of occasional outliers of conglomerate on the Highland side of the fault. One of the most striking features in the formation is the enormous development of its contemporaneous volcanic rocks. These are underlaid in Kincardineshire by about 5,000 feet of sandstones and shales, and they pass under the grey flags and conglomerates of Forfar, and an upper series of red and purple sandstones. They consist of thick sheets of various porphyries with beds of tuff and enormous masses of coarse volcanic conglomerates. Zones of grey flagstones, including the well-known beds of Carmylie near Arbroath, are intercalated in them. In the Ochil Hills, according to the measurements of Mr. B. N. Peach, this volcanic zone reaches a depth of not less than 6,500 feet. It runs from the sea-coast at Dunottar through the chain of the Sidlaw and Ochil Hills to near Stirling. It reappears south of the Forth, in the Pentland chain, and stretches south-westwards in great force across Lanarkshire and Ayrshire. The author then alluded to the fossils hitherto noticed in this part of the Old Red Sandstone in different parts of Britain, pointing out the contrast they present to those of the preceding Silurian rocks. He showed that in Forfarshire the well-known crustaceans and fishes had been obtained from strata, lying not as hitherto supposed at the base of the system, but several thousand feet higher, and that the fish-bed found by Mr. Mitchell in Kincardineshire, and supposed by Sir Roderick Murchison to indicate from its Acanthodian forms an approach to the middle Old Red Sandstone, really lay below the position of the Turin flagstones so well explored by Mr. Powrie.

The so-called "Middle" Old Red Sandstone is not known certainly to exist anywhere else in Britain than in the north of Scotland. This subdivision was introduced by Sir R. Murchison, and is based wholly on the evidence from fossils. It presents a remarkably distinct series of ichthyolites, which have not been met with in the Lower Old Red Sandstone of the south, and which have therefore been held to mark a higher series of deposits. The "Middle" Old Red Sandstone is typically developed in the well-known flags of Caithness. Those strata, long since described by Sedgwick and Murchison, cover nearly the whole of that county, and stretch into the Orkney and Shetland Islands. The author had measured a section of these on the east coast of Caithness more than 8,000 feet in thickness. They show conglomerates and red sandstones at the base, and similar strata reappear on different higher horizons. But on the whole, the series consists of dark-grey, hard, fine-grained flagstones, sometimes bituminous, often calcareous, and frequently abounding in remains of fishes, entomostraca, and land-plants. No evidence of contemporaneous volcanic action has yet been met with in these rocks. The general character of the whole series differs in many respects from that of the Old Red Sandstone on the south side of the Grampians, and appears to indicate widely different conditions of deposit. The basins in which the Caithness flags, and the Arbroath flags accumulated, were separated by the intervening mass of the Inverness-shire and Aberdeenshire highlands, as shown by the basement conglomerates on each side of the mountains. The author then dwelt on the fossil evidence and its bearings. He suggested that it could not be held to prove a "middle" series, and that it was not inconsistent with the idea that the Caithness flags really belonged to the Lower Old Red Sandstone, the peculiarities of their fauna not being greater than might be due to great differences of physical geography, and to the fact that the respective areas of deposit were isolated from each other. He further pointed out that some of the most characteristic forms of the lower group occur in the Caithness and Orkney beds, *e.g.*, *Pteraspis*, and *Pterygotus*. The Caithness flags abound in land-plants like *Sigillaria*, *Lepidodendron*, and some of the peculiar Devonian forms found by Dr. Dawson in Gaspé. Some of these latter forms have recently been detected by Mr. R. L. Jack in the course of the work of the Geological Survey in Perthshire.

The red and yellow sandstones, red clays, and red conglomerates and breccias, included under the term "Upper Old Red Sandstone," are copiously developed in Wales, in Ireland, and in the south of Scotland. In the two last-named regions they have been shown to lie unconformably on all older formations, there being a complete physical discordance, and an entire difference in organic contents, between these strata and the Lower Old Red Sandstone. In South Wales a less marked break in the series may be suspected from the cautious descriptions given by Sir Henry De la Beche. In the north of Scotland Sir R. Murchison has described the Upper as graduating downwards into the Middle or Caithness flags. In Caithness itself, however, and in Orkney, they are completely discordant, and the same relation may be inferred to hold elsewhere. This uppermost member thus bears the same relation to the Caithness flags as to the Arbroath flags. Wherever the top of the series can be seen, it is found to pass gradually and conformably into the base of the Carboniferous system. So thoroughly do these two series of deposits dovetail with each other that no sharp line can be drawn between them. If we work our way into the red rocks from the Carboniferous side, we may claim them as merely the base of the Carboniferous system. If we approach them from the side of the Old Red Sandstone, we may well regard them as a late and unconformable sub-division of this system.

The author next adverted to the fossils peculiar to the Upper Old Red Sandstone, calling attention to the continuance of land-plants and ganoid fishes as characteristic Old Red Sandstone features. He then, in conclusion, pointed out the physical geography which appears to be indicated by the deposits of this period. It is still possible to map out some of the terrestrial and lacustrine areas which then marked the site of Britain. Hill-ranges, still in existence, formed prominent features in the landscapes of that time, though with many differences of outline; in particular, with water-filled bays, straits, long fjord-like inlets and scattered lakes which have been filled up with sandstones, conglomerates, and breccias. The red stain of these deposits, occasional pseudomorphs of rock-salt and layers of gypsum, combined with ripple-marks and sun-cracks seem, as Prof. Ramsay has suggested, to indicate the concentration of the saline waters which filled these basins; while further evidence of the unwholesome nature of the water may be indicated by the general paucity of fossils in the strata, and by the immense numbers of well-preserved fishes which are sometimes met with crowded into a small space, as if they had come from fresher water elsewhere, and had been inclosed and killed in scattered pools. The peculiar breccias and brecciated conglomerates of the Upper Old Red Sandstone have been compared to some recent Glacial deposits, and the resemblance has been pointed out between the form of the stones in these deposits, and those in common boulder-clay. It should be noted also that in many cases these breccias occur in old valleys, and bear many of the characters of valley-moraines. Such are those to the east of Ullswater, and those which flank, and in some places penetrate the Lammermuir Hills. In the latter district worn dome-shaped bosses of rock underlying the breccias recall the aspect of true *roches moutonnées*. Another glacial feature is suggested by the basin-shaped hollows (apparently sometimes true rock-basins) in which the deposits lie. Further indications of ice are given by the remarkable patches of angular and rounded stones scattered through the red sandstones of Arran, the occurrence and position of which may be accounted for on the supposition that they are portions of shore-gravel, which have been frozen and transported in cakes of floating-ice.

Indications of terrestrial disturbance during the accumulation of the Upper Old Red Sandstone in Scotland are furnished by the Lammermuir Hills. Towards the close of the period, and thence through the deposition of the Lower Carboniferous rocks, volcanic action which seems to have been quiescent for a long interval, broke out again over the south of Scotland. To this period belongs the chain of old lavas and tuffs which may be traced from the mouth of the Nith eastwards by Langholm and the Tarras Water, to the head of the Slitrig Valley, and through the plain of the Tweed as far northwards as the Whiteadder. The Garlton Hills, Campsie Fells, and the ranges of hills which run down Renfrewshire and the north-east of Ayrshire, and are prolonged into Bute, the Cumbrays and Arran mark a prolonged series of volcanic eruptions during this same period. Probably the terraced hills of Lorne are of similar age. Traces of contemporaneous volcanic action occur likewise in the Upper Old Red Sandstone of the north of Scotland, and form a remarkable feature in the cliffs of Hoy, one of the Orkney Islands.

The author brought forward evidence to show that while the Upper Old Red Sandstone was being deposited in the British area, there existed outside that area a sea in which some of the characteristic corals, brachiopods, and other organisms of the time of the Carboniferous Limestone already existed. He pointed out the intercalation of limestone bands in the Red Sandstone series in Arran and elsewhere, a long way below the base of the Cement-stone group which underlies the Carboniferous Limestone. These calcareous bands, full of species of fossils which are familiar in the Carboniferous Limestone, seem to indicate that while, on the whole, the Upper Old Red Sandstone, and the red strata at the base of the Carboniferous system were deposited under conditions unfavourable to the presence of at least corals, crinoids, and molluscs, their formation was interrupted by intervals during which clearer and less saline water prevailed, perhaps owing to the removal of barriers which allowed the access of the main ocean with its animal forms into the closed lagoons and inland seas of the Upper Old Red Sandstone.

ON REPULSION RESULTING FROM RADIATION[1]

THIS paper contains an account of experiments on the action of radiation on bodies the surfaces of which have their radiating and absorbing powers modified by various coatings. The difference between a white and a lamp-blacked surface in this respect was at first not very decided, and experiments have been instituted with the object of clearing up some anomalies in the actions observed. Two pith discs, one white and the other black, are suspended on a light arm in a glass bulb by means of a fine silk fibre; after perfect exhaustion the white and black discs are found to be equally repelled by heat of low intensity, such as from the fingers, warm water, &c. A copper ball is then tried at gradually increasing temperatures. Up to 250° C. it repels both equally, above that the black is more repelled than the white, and at a full red heat the repulsion of the black disc is very energetic. A lighted candle acts with more energy than the red-hot copper.

The presence of even a small quantity of aqueous vapour in the exhausted apparatus almost, if not quite, neutralises the more energetic action which luminous rays appear to exert on a blackened surface.

After describing several different modifications and some new forms of apparatus devised to facilitate experiment, the author gives a drawing of an instrument which enables him to get quantitative measurements of the amount of incident light falling on it. It consists of a flat bar of pith, half black and half white, suspended horizontally in a bulb by means of a long silk fibre. A small magnet and reflecting mirror are fastened to the pith, and a controlling magnet is fastened outside so that it can slide up and down the tube, and thus increase or diminish sensitiveness. The whole is completely exhausted and then inclosed in a box lined with black velvet, with apertures for the rays of light to pass in and out. A ray of light reflected from the mirror to a graduated scale, shows the movements of the pith bar. The degrees of deflection produced by the light of a candle at distances from 6 feet to 35 feet are given.

The experimental observations and the numbers which are required by the theoretical diminution of light with the square of the distance, are sufficiently close, as the following figures show:—

				°
Candle	6	feet off	gives a deflection of	218
”	12	”	”	54
”	18	”	”	24·5
”	24	”	”	13
”	10	”	”	77
”	20	”	”	19
”	30	”	”	8·5

The effect of two candles side by side is practically double, and of three candles three times that of one candle.

The action of various solid and liquid screens is next given.

A candle three feet off, giving a deflection of 180°, has its action reduced to the following amounts by

	°
Yellow glass	161
Blue ”	102
Green ”	101
Red ”	128
Water ”	47
Alum ”	27

A candle on each side of the apparatus, and equidistant from it, keeps the index ray of light at zero; by shading off either one or the other the light flies off to either extremity of the scale. This gives a ready means of balancing two sources of light one against the other. Thus,

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[1] Paper read at the Royal Society, Feb. 10, by William Crookes, F.R.S., &c. Part III.